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A COMPARISON OF CATCHER-PROCESSOR VESSEL AND CATCHER VESSEL FISHING PERFORMANCE IN THE 1988 BERING SEA RED KING CRAB FISHERY

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Abstract

The Bering Sea red king crab population is fished by a fleet whose composition contains a significant number of catcher-processor vessels in operation. During the 1988 fishery, on-board observers were placed on these vessels, for the first time. We have examined the catch per unit effort (CPUE) for catcher vessels and catcher-processor vessels operating in the Bering Sea. In the 1988 fishery, the average pounds landed per catcher vessel was approximately 36,000 compared with an average of approximately 50,000 for the catcher-processor vessels. The landing rate was 51 pounds per pot-lift versus 48 pounds per pot-lift respectively. In 1988, the pounds landed per pot-lift, and pounds landed per number of registered pots of catcher-processor vessels were not significantly larger than the catcher vessels but were highly significant in 1987. Therefore we conclude that the observer program which was instituted in the 1988 fishery had a high likelihood of being responsible for the similarity in the catch per unit effort reported by the catcher fleet and the catcher-processor fleet.

Introduction

This report is a continuation of the previous examination of the differences in catch rates observed between catcher-processor vessels and catcher vessels participating in the Bristol Bay red king crab fishery. The previous report, hereafter referred to as the 1987 Report[2], addressed differences in the 1987 fishery observed before implementation of a mandatory on-board observer program by the Alaska Board of Fisheries in the spring of 1988. The Bristol Bay red king crab fishery was the first implementation of this observer program. The differences in catch rates reported in the 1987 Report was one of the factors considered by the Board of Fisheries in establishing the mandatory observer program. This report addresses the catch rates observed between the catcher-processor fleet and the catcher fleet during the 1988 fishery and compares these results with the 1987 Report.

The increased numbers of catcher-processor vessels that participated in recent Bering Sea red king crab fisheries stabilized in 1988 with 20 participating catcher-processor vessels as compared with 21 in 1987. A combination of the observer requirement, and the decreased guideline harvest level were probable contributors to this stabilization. Some vessels, capable of processing at sea, elected to operate as catcher only vessels, or process crab near shore-based facilities which exempted these vessels from the mandatory observer requirement. There has been an overall increase of 11 catcher-processor vessels since 1986.

This report examines apparent differences in catch rates between the catcher-processor vessels and catcher vessels in the 1988 fishery. As processing of sub-legal crab by catcher-processor vessels is not a probable explanation of any differences in the pounds landed during the 1988 fishery, such differences, if they exist, are most likely explained by other factors. Because of the small number of landings in each statistical area, and the inconclusive results obtained from examination of area of landings in the 1987 Report, we have excluded this variable from the analysis. The vessel size, the number of pots registered, and the number of pots lifted are examined in this report, similar to the 1987 Report. Because of the short duration of the 1988 fishery (7-days), most of the vessels made a single delivery. When more than one delivery was made, the pots were continually soaked. Because of these factors, differences in actual days fished were considered insignificant and are accounted for by the reported number of pot-lifts. The number of pots registered was considered to be somewhat imprecise, but there is no apparent reason for a catcher vessel to misreport number of pots registered differently than a catcher-processor vessel. The use of numbers of pots registered provides an alternative method of examining the effective amount of effort of a given vessel. Catch per unit effort was projected by using the reported number of pot-lifts and the number of pots registered as the effort.

Therefore, the objective of this analysis is to determine if the pounds landed and the catch per unit effort (CPUE) were significantly different for the catcher-processor vessels in the 7-day fishery held during September 1988 and to determine if on-board observers had an

[2]Schmidt, D. and B. A. Johnson. 1988. A Comparison of Catcher-Processor and Catcher Vessel Fishing Performance in the 1987 Bering Sea Red King Crab Fishery. Regional Information Report No. 4K88-14. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak.

impact. If such differences occurred, we examined if these differences can be explained by known differences between the two types of vessels. We will also examine the economic implications of the 1988 catch rates as compared to the 1987 catch rates.

Methods

The methods used are the same as those reported in the 1987 Report. We have excluded examination of the areal differences because of the small number of landings which occurred in each statistical area by catcher-processor vessels. This makes comparisons between the two types of vessels with respect to area fished, of limited value. The data used in this analysis were obtained from the fish tickets, the list of vessel type, and vessel registration forms. For catcher-processor vessels, a single fish ticket was usually submitted for the entire season, although on longer fisheries, a fish ticket is completed weekly. For catcher vessels, a ticket is completed at each landing. The basic data from the fish tickets consisted of pounds landed, number of crab landed, and number of pot-lifts. The basic data from the vessel registration forms consisted of numbers of pots registered and length of vessel. The data resolution is that of vessel, i.e. multiple fish tickets were combined for a single vessel.

To check for outliers in catch per unit effort or pounds landed, graphical methods of analysis were used. For testing differences in means we used the t-test for two independent samples (Snedecor and Cochran 1967) and the non-parametric test for the same, known as the Mann-Whitney or Wilcoxon rank sum test (Conover 1980).

In addition to the t-test and rank sum test to test for differences in the means of the two vessel types, a graphical method was used to locate differences in the sampling distributions of these data. The analysis of distributional differences was necessary because we could easily have had a segment of the catcher-processor fleet that landed crab at normal or sub-normal rates, while another segment of the catcher-processor fleet that experienced very high landing rates. Differences in means may be very minor in this case, but distributional differences could be very large.

We chose to use a graphical method to illustrate the distributional differences. The quantile-quantile plot or Q-Q plot (Chambers et al. 1983, Hoaglin et al. 1983, and Gnanadesikan 1977) can be used to determine if a sample distribution is similar to some other distribution. In addition to differences in the mean, other similarities or dissimilarities are observable.

Results

Graphical techniques were used to identify patterns in average crab weight, catch per unit effort, and other variables. From these patterns we identified outliers and errors in the data. By checking for outliers, one vessel was removed from the analysis because the average weight of the catch for that vessel was extremely low and not within the range of the other 198 vessels (Appendix A). The vessel also was the smallest vessel with the smallest catch. The average weight of the crab reported appeared to be below that expected for legal crab, suggesting possible errors in either the weight or the number of crab reported.

The difference in means was measured by use of a t-test. With this test, we determined if two average numbers were different and if different, we assigned a probability to the significance of that difference. The first theoretical problem encountered was the normality assumption for the t-test. This assumption did not always hold. The Wilcoxon test is robust under violation of this assumption and was used as an alternative for comparison. For pounds landed, the square root transformation did result in normalized data. The other variables in this study showed similar results after transformation by either natural logarithm or square root transformations. Before each test a normality plot was obtained for the transformed and untransformed variables to determine the appropriate transformation.

Comparisons of Pounds Landed and CPUE for 1988

All mean values for each variable except the pounds per pot-lift and pounds per pot registered were significantly greater for the catcher-processor vessels as indicated by the test statistics (Table 1). This differs from the 1987 fishery data, in that the mean values for all variables were significantly greater for the catcher-processor vessels in 1987.

Table 1.—Test statistics for difference in mean values between catcher-processor vessel (N=20) and catcher vessel (N=178) (t-test was applied to the appropriate square root or natural log transformed data).

	Mean values			P-value	
Variable	Catcher vessel	Catcher-processor vessel	Ratio of means	Wilcoxon test	t-test
Pounds landed	35766	49727	1.39	0.002	0.004
Number of pot-lifts	705	1039	1.47	<0.001	<0.001
Pounds per pot-lift	50.7	47.9	0.94	0.388	0.483
Number of pots registered	237	376	1.59	<0.001	<0.001
Pounds per pots registered	145.7	134.7	0.92	0.444	0.360
Vessel length (ft)	101	153	1.51	<0.001	<0.001

The P-values for the two statistical tests indicate the probability of differences in means between the catcher vessels and catcher-processor vessels being caused solely due to chance. The 0.002 value, for example, indicates that there is less than 2 chances in 1000 that the 13,961 pound difference between the mean values 35,766 and 49,727 pounds landed is not significantly different from zero.

To illustrate the difference in the distribution of pounds landed, the catcher-processor values (dots) were compared to the catcher vessel distribution (solid line) in the Q-Q plot in Figure 1. If the catcher-processor distribution was the same as the catcher vessel distribution, the dots would occur randomly around the solid line.

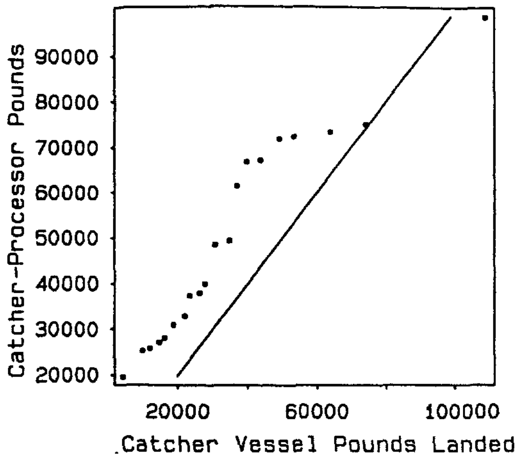

Figure 1. Catcher-processor pounds landed compared to catcher vessel distribution.

Notice that in Figure 1 all but two of the points of the catcher-processor vessels are above the solid line. Each dot represents a catcher-processor vessel. The y-axis shows the actual pounds landed and the x-axis shows the pounds landed by an equivalent catcher vessel. Over the period of the fishery, the majority of the catcher-processor vessels consistently had greater pounds landed than the catcher vessels. The vertical difference from the solid line to each dot reflects the difference in pounds between an equivalent catcher-processor vessel and catcher vessel.

Although the difference in average pounds landed between the two vessel types is significant ($\mathbf{P}<0.01$), the pounds landed may be affected by the number of pot-lifts or the size of vessel. As an alternative measure of effort, registered number of pots was also used as a comparative basis. For both measures of CPUE, the catcher-processor vessels did not have significantly different values when compared to the catcher vessels (Table 1).

Because catcher-processor vessels are much larger vessels, on average, than the catcher vessels, we further examined the data to determine if length of vessel would explain the differences observed. To provide similar size classes of both catcher-processor and catcher vessels, vessels of 130–170 feet were selected. In addition, this size group allows a comparison with the 1987 Report. This group included 12 catcher-processor vessels and 23 catcher vessels. As in the 1987 Report, the pounds landed were not dependent upon vessel length (Figure 2). This grouping provided sufficient numbers of vessels and low significant difference of length ($\mathbf{P}=0.09$) (Table 2).

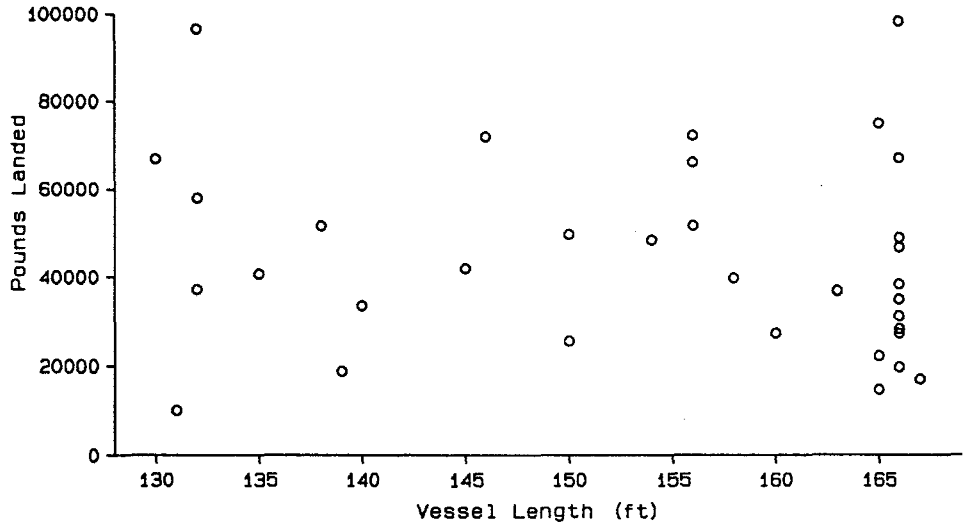

Figure 2. Scatter plot of pounds landed versus vessel length (N=35).

Table 2.—Test statistics for difference in mean values between catcher-processor vessel (N=12) and catcher vessel (N=23) with length between 130 ft and 170 ft (t-test was applied to the appropriate square root or natural log transformed data).

Variable	Mean values		Ratio of means	P-value	
	Catcher vessel	Catcher-processor vessel		Wilcoxon test	t-test
Pounds landed	40131	53817	1.34	0.060	0.048
Number of pot-lifts	795	1043	1.31	0.004	0.003
Pounds per pot-lift	54.4	50.9	0.94	0.473	0.391
Number of pots registered	316	410	1.30	<0.001	<0.001
Pounds per pots registered	126.9	132.4	1.04	0.327	0.407
Vessel length (ft)	151	158	1.05	0.090	0.090

For vessels of size 130–170 feet in length, there is still a statistical difference between mean pounds landed, however it is not highly significant (**P**=0.06). Neither measure of CPUE shows a statistical difference between catcher-processor vessels and catcher vessels (Table 2). The number of pot-lifts is still significantly greater for the catcher-processor vessels.

Comparisons of 1987 and 1988 Fisheries

We have analyzed the 1988 Bering Sea red king crab fish ticket data in an attempt to determine if a disparity existed in pounds landed between the catcher vessels and the catcher-processor vessels. If a disparity exists, it is unlikely to be caused by illegal catch because all catcher-processor vessels had observers on-board during the 1988 fishery. There was a significantly larger average catch for the catcher-processor vessels in the 1988 fishery (Table

1). However, the CPUE was not significantly different when considering pounds per number of pot-lifts or pounds per number of pots registered. This combined with a significantly greater number of pot-lifts for the catcher-processor vessels would explain the larger catch. The comparative values were different from those observed during the 1987 fishery. The comparison is best presented graphically and by comparing the 1987 and 1988 pounds landed, the difference between the catcher-processor vessels and catcher vessels within year and between years is quite evident (Figure 3).

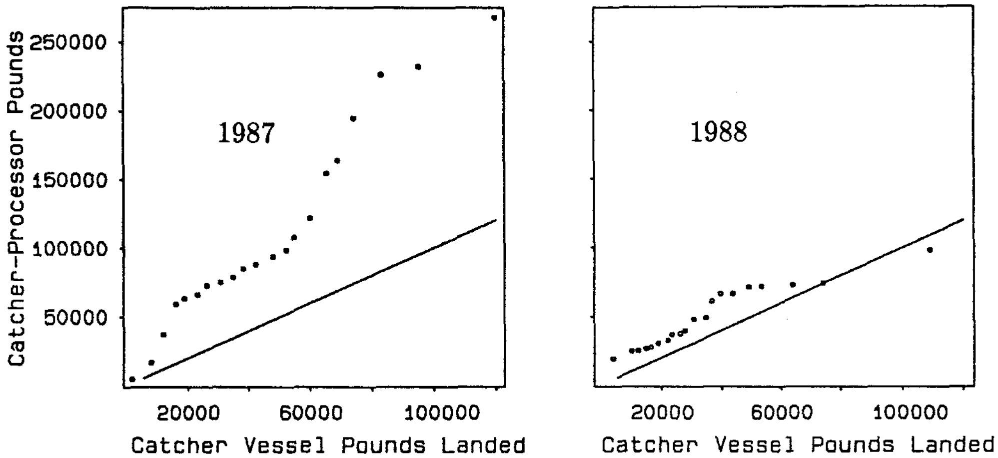

Figure 3. Comparison of 1987 and 1988 catcher-processor pounds landed compared to catcher vessel distribution.

The 1988 data in Figure 3 is repeated from Figure 1 with a scale adjustment to provide a visual comparison with the 1987 data. In Figure 3, each dot represents a catcher-processor vessel. The y-axis lists the pounds landed by the catcher-processor vessels and the x-axis represents the pounds landed of an equivalent catcher vessel. By comparing all of the dots relative to the solid line, the 1988 distribution of pounds landed for the catcher-processor vessels is essentially parallel to the catcher vessel line and illustrates that the catcher-processor vessels had an overall larger catch, but the distributions have a variability much more similar than during 1987. The closeness of the points to the line in 1988 versus 1987 illustrates that the distribution of pounds landed in 1988 by the catcher-processor vessels is much more similar to the catcher vessels than during the 1987 fishery. The average difference in pounds landed for the catcher and catcher-processor vessels was approximately 14,000 in 1988 versus 63,000 in 1987.

Pounds per pot-lifts in 1987 was significantly greater for catcher-processor vessels, but not during the 1988 fishery. The comparison between the two years is shown in Figure 4.

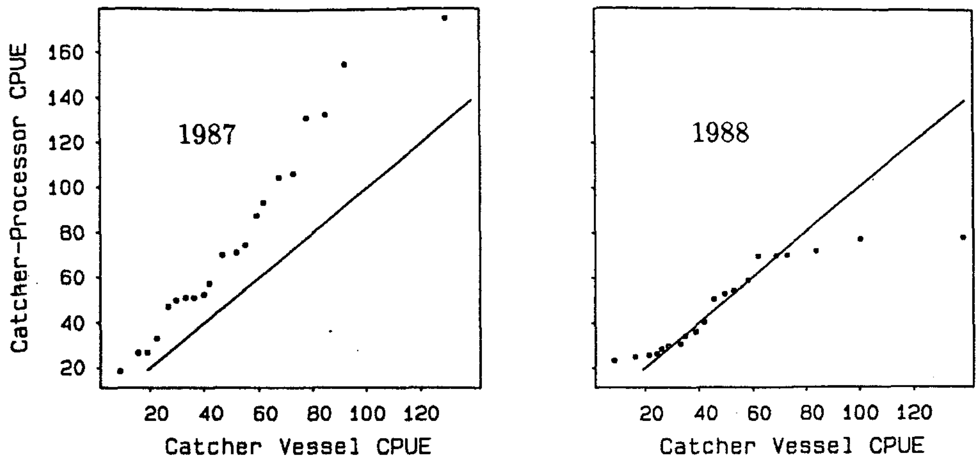

Figure 4. Comparison of 1987 and 1988 catcher-processor pounds landed per pot-lift compared to catcher vessel distribution.

In Figure 4, each dot again represents a catcher-processor vessel. The y-axis lists the CPUE of the catcher-processor vessels and the x-axis represents the CPUE of an equivalent catcher vessel. By comparing all of the dots relative to the solid line, CPUE for the catcher-processor vessels are essentially the same as the catcher vessels, in 1988. The several data points on the upper tail of the distribution fall below the line but do not alter the conclusion that these distributions are similar.

Although the lack of statistical difference in the mean CPUE for vessels of all sizes is a logical stopping point, we also present a comparison of the 1987 and the 1988 data for vessels 130 ft to 170 ft. The same patterns hold as with the vessels of all sizes and can be illustrated in the same manner through Q-Q plots. The distribution of pounds landed per catcher-processor vessel in 1988 shows less variation than in 1987 and is more similar to the catcher vessels (Figure 5). The CPUE for catcher-processor vessels in 1988 is essentially the same as catcher vessels; differing from the illustrated distribution in 1987 (Figure 6).

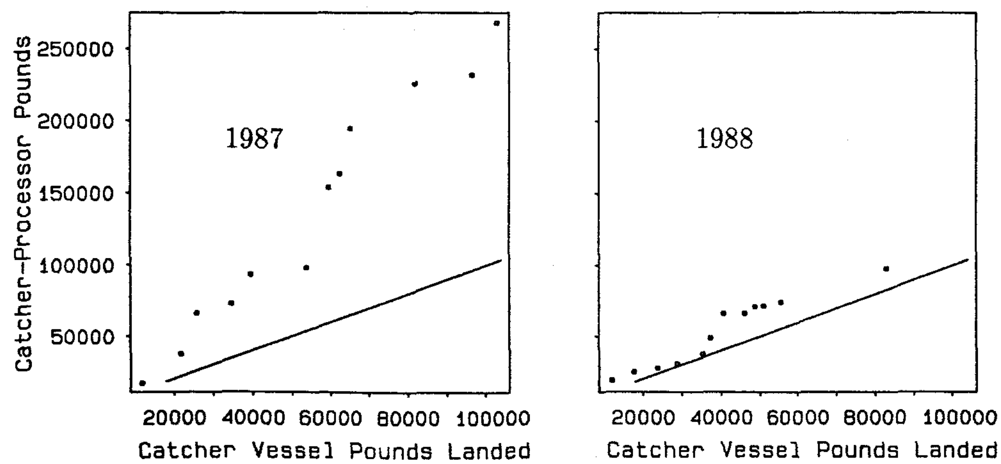

Figure 5. Comparison of 1987 and 1988 catcher-processor pounds landed compared to catcher vessel distribution (vessels 130–170 ft).

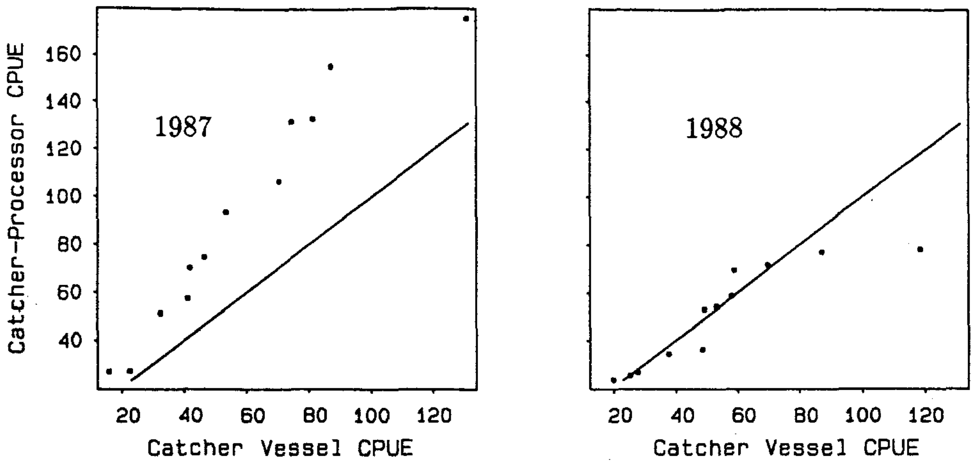

Figure 6. Comparison of 1987 and 1988 catcher-processor pounds landed per pot-lift compared to catcher vessel distribution (vessels 130–170 ft).

Table 3 tabulates the differences in the catch values between 1987 and 1988 for both vessel types between 130 and 170 ft in keel length. The pounds landed by the catcher-processor vessels in 1988 were approximately 1.3 times higher than the catcher vessels, when considering vessels of similar length. This compares with 2.5 times higher in 1987. It is a safe assumption that the pounds landed are relatively free from reporting errors. When comparing the vessels in total, the catcher-processor vessels had landings that were 1.4 times larger that of the catcher vessels in 1988 versus 2.3 times larger in 1987.

Table 3.—1987 and 1988 mean values for catcher-processor vessel and catcher vessel with length between 130 ft and 170 ft.

	Catcher vessels		Catcher-processor vessels		Ratio of means	
Variable	1987	1988	1987	1988	1987	1988
Pounds landed	54844	40131	136074	53817	2.48	1.34
Number of pot-lifts	1013	795	1396	1043	1.37	1.31
Pounds per pot-lift	58.5	54.4	92.4	50.9	1.58	0.94
Number of pots registered	300	316	398	410	1.32	1.30
Pounds per pots registered	183.0	126.9	330.3	132.4	1.80	1.04
Vessel length (ft)	152	151	155	158	1.01	1.05

The average number of pot-lifts as reported on the fish tickets was significantly larger for the catcher-processor vessels, for vessels of all lengths, and when only vessels of similar size were compared. The number of pot-lifts of the catcher-processor vessels relative to the catcher vessels in 1988 (1.31) is very similar to the same ratio for 1987 (1.37) (Table 3).

Discussion

Analysis of vessels of all lengths indicates that catcher-processor vessels had average pounds landed per pot-lift essentially identical to that of an average catcher vessel. When the vessels compared were vessels of similar keel lengths, average pounds landed per pot-lift by catcher-processor vessels was again not significantly different than that reported by the catcher vessels.

Differences in pounds per vessel and pot-lifts per vessel were significantly higher in 1988 for catcher-processor vessels when compared to either similar sized catcher only vessels or all catcher only vessels. As this difference is confirmed by observers, and the larger number of pots registered also reflects this difference, apparently processing vessels in this size range can fish more pots and also pull significantly more pots. Larger crews and possibly more deck space may be an explanation.

The difference in average catches between catcher-processor vessels and catcher vessels can be explained by the difference in the number of pot-lifts. No significant differences between these vessel types remains, once this variable is taken into account.

From the previous discussion, it appears that parity in the fleet has been obtained by the presence of mandatory observers on the catcher-processor vessels. The economic advantage, beyond the processing capabilities, is now explainable by an increased number of pots fished and an increased number of pots lifted.

In addition, the relative number of pots lifted by catcher-processor vessels compared with catcher only vessels in 1988 and 1987 was similar. This would indicate that the on-board observers did not reduce the fishing efficiency of the catcher-processor vessels.

The economic impact of the observer program can be estimated by some simple comparisons. The average price per pound for the red king crab fishery was estimated at $5.10. If we assume the differential pounds landed per vessel between the 1988 and 1987 red king crab fisheries was entirely due to the observer, the following approximate redistribution of ex-vessel product value can be projected for the 1988 Bristol Bay red king crab fishery if an observer were not present. This projection assumes that illegal landings of small crab are the total cause of the differences observed between 1987 and 1988 and the difference in catch rates observed in 1987 between catcher-processor vessels and catcher only vessels would have occurred in 1988. The estimates are based on the assumption that the fishery still would have closed when the 7.3 million pound total harvest of crab was reached.

Table 4.—Estimated economic impact of the on-board observer program during the 1988 fishery.

Vessel type	Actual pounds per vessel	Total pounds	Projected without an observer: Pounds per vessel	Projected without an observer: Total pounds	Projected change: Pounds	Projected change: Value per boat	Projected change: Total value
Catcher-Processor	49,727	994,546	76,599	1,531,985	537,439	$137,047	$2,740,939
Catcher	35,766	6,366,377	32,747	5,828,938	-535,000	-$15,399	-$2,740,939

The average values may be deceptive in that catcher-processor vessels which fished legally prior to having observers would actually, on average, experience a gain similar to the catcher vessels. If the difference is due solely to illegal landings, the vessels which had reduced catches because of observers, experienced major losses. These losses dwarf the actual cost of providing for an observer. The revenue increase to the legal catcher-processor vessels, because of extra fishing time, probably offsets more than the cost of the observer.

Conclusions

We examined the pounds landed as a function of the number of vessels, the number of potlifts, and the number of pots registered to determine if significant differences occurred. With an on-board observer the pounds landed for catcher-processor vessels was still significantly larger in 1988. However, the CPUE indicated that both types of vessels showed the same fishing efficiency. If this is a true measure of fleet fishing effectiveness, then the 1987 CPUE for catcher-processor vessels was unreasonably high. This would lead to the conclusion that illegal crab were taken during the 1987 fishery. To provide equal enforcement of size and sex regulations established for this fishery it is essential that a mandatory on-board observer program continue. The costs of continuing this program are very small when compared with the potential value of illegal crab taken by unobserved processing vessels.

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Appendix A

The first step in the analysis identified an anomaly in the observed data that indicated a catch of underweight crab that either indicated a wrong count in the number of crab or incorrect pounds landed. The amount of the landing was extremely small, and considering the short length of the vessel, we concluded that the vessel was not participating in the fishery in a similar manner as the remainder of the fleet. The extreme difference can be seen in Figures A1 and A2.

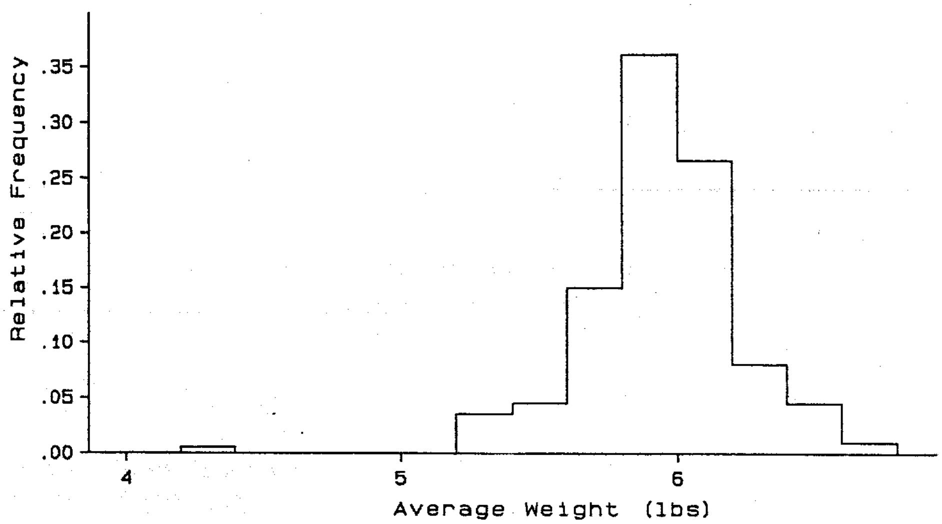

Figure A1. Distribution of average crab weights and identification of outlier.

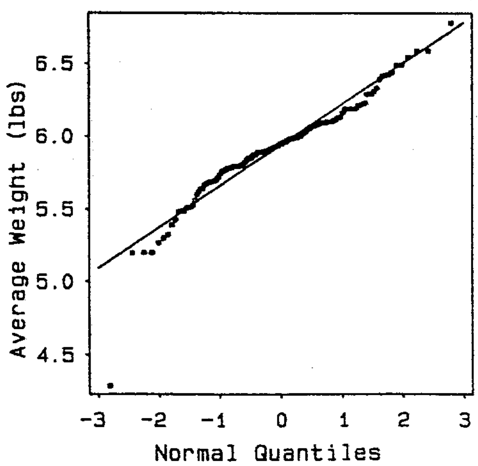

Figure A2. Normal plot of average crab weights and identification of outlier.